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TIDAL TANK SYSTEM IN OPERATION AT THE EDWARD PERCIVAL MARINE LABORATORY, KAIKOURA

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ABSTRACT

The design and performance of a tidal tank system, currently in operation at the University of Canterbury Edward Percival Marine Laboratory, are discussed. This system recirculates 2,500 l of seawater: rise-and-fall of water is sinusoidal with respect to time, tidal period is fixed at 12 h 31 min, mid-tide level may be set where desired, and tidal amplitude may be fixed within the range 0.20-0.55 m at 0.05 m intervals. There are two tidal tanks, each 1.5 m by 0.75 m by 0.6 m deep.

INTRODUCTION

There have been many recent studies using laboratory tide models to investigate the behaviour of intertidal invertebrates (Evans 1965, Lambert and Farley 1968, Thompson 1968, Micallef 1969, Morton 1970, Ottaway and Thomas 1971, Ottaway 1973). The various types of tide model were discussed by Underwood (1972) and those with sinusoidal rise-and-fall of water seem to be most useful for biological applications (Evans 1964; Micallef 1967; Thompson 1968). This paper describes a sinusoidal tide model which has been operating successfully for almost one year.

GENERAL INFORMATION

All seawater pipes, taps and valves in the marine laboratory and tidal tank system are either unplasticised polyvinyl chloride (PVC) or thick-walled polythene. Water is fed into the tidal tank system as required from the main laboratory supply, which in turn is pumped directly from the sea to outside storage tanks. Water in the tidal tank system is only replaced during periods when the laboratory supply is at least relatively free of silt and detritus.

The environment within the laboratory tank room is not controlled: air temperatures and relative humidities vary in the approximate ranges 10-30°C and 55-80% respectively. Water temperatures in the tidal system vary in the range 10-20°C. Magnitude and mean of fluctuations for any given period depend on the prevailing weather.

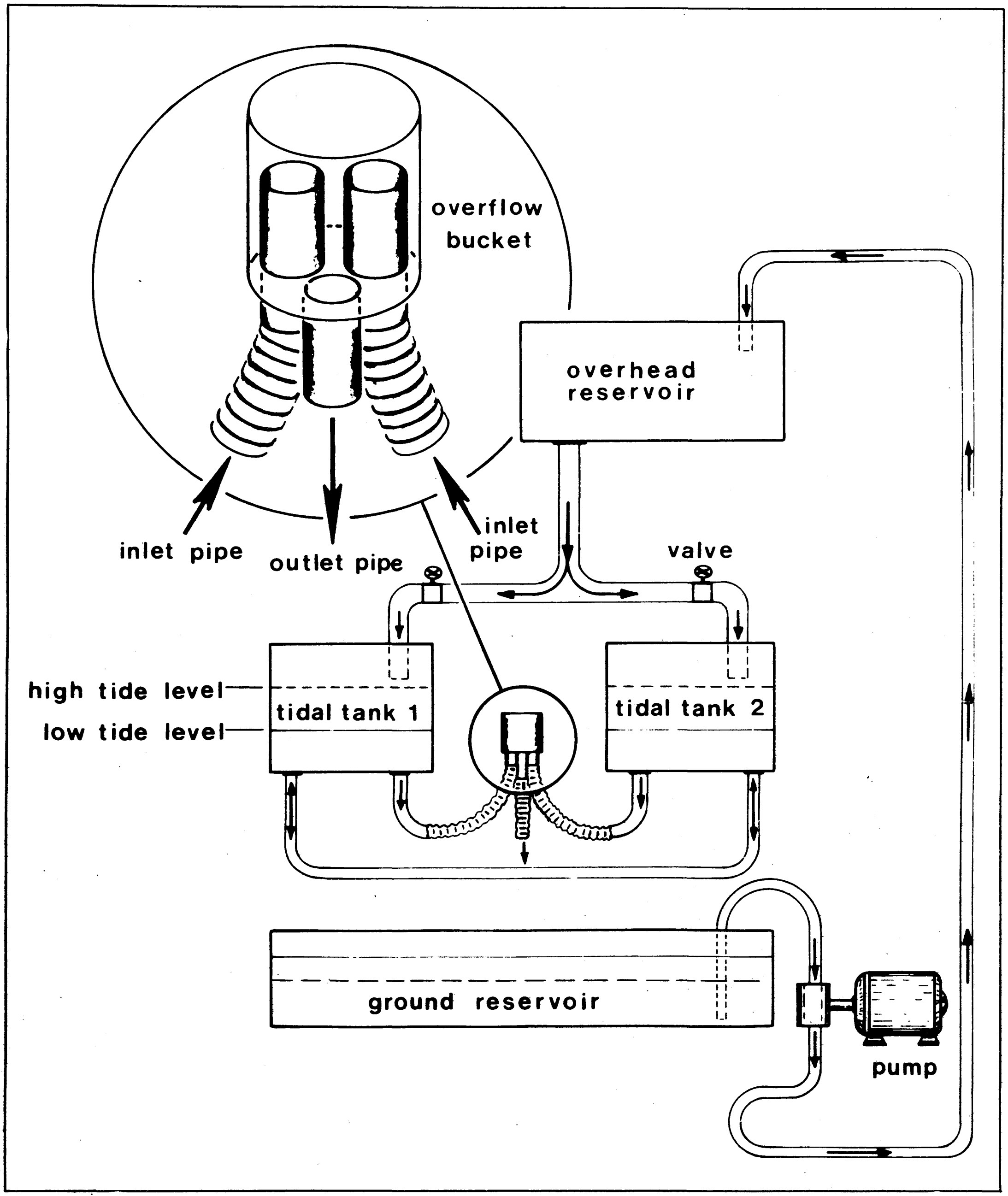


Fig. 1. Schematic representation of recirculation system. Arrows indicate direction of water flow. Inset: enlarged representation of overflow bucket.

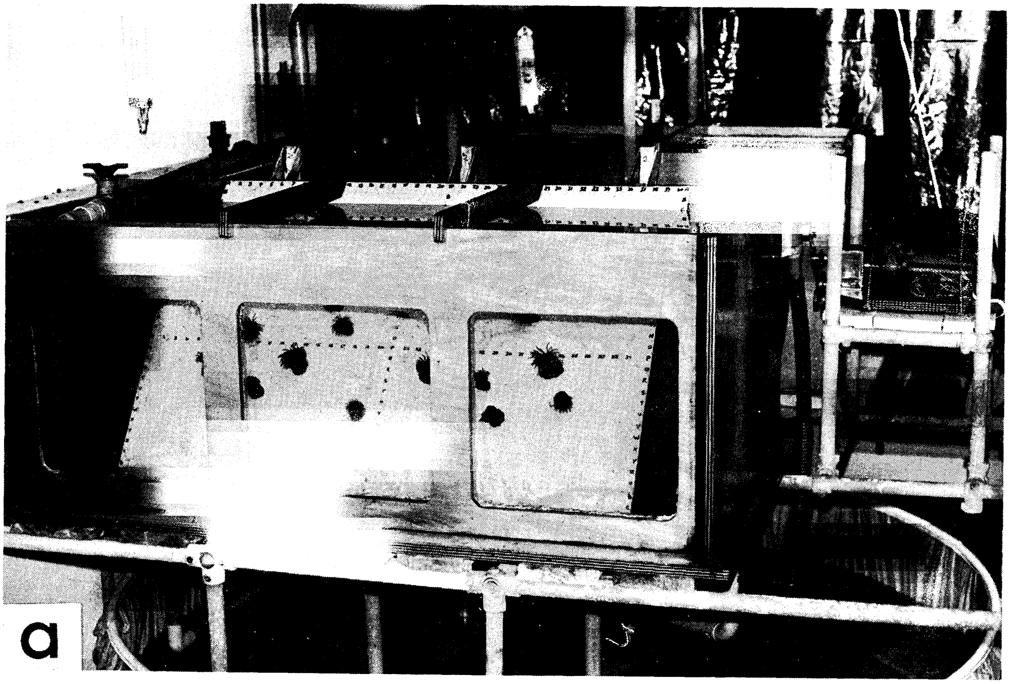
TIDAL CYCLE MECHANISM

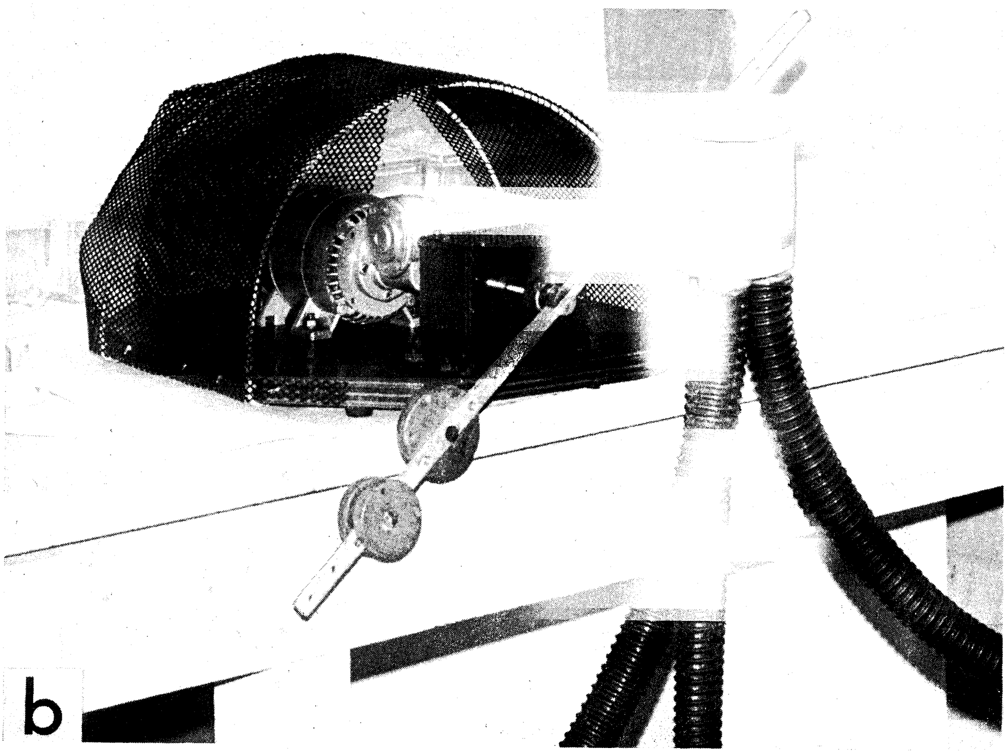
The Kaikoura tide model is based on those described by Evans (1964) and Underwood (1972). Water recirculates continuously through the system: from an overhead reservoir through two experimental tidal tanks to a ground reservoir and then back to the overhead reservoir (Fig. 1). Surplus water from the experimental tanks flows away through flexible corrugated PVC tubing to a moving overflow bucket (Fig. 1; Fig. 2b), which is attached by a swivel to a counterbalanced beam. The beam is driven by a single phase induction motor (1400 rpm, 10W 240v, output 60 cmkp: Parvalux Electric Motors, Bournemouth) geared down to give one revolution every 12 h 31 min. The circle described by the bucket, during each tidal period, determines the water level in the experimental tanks (Fig. 3). One inlet tube from each of the two tidal tanks enters the base of the bucket and continues vertically for 10 cm. Water spills from these pipes, drains away through an outlet in the base of the bucket, and then falls directly into the ground reservoir.

Tidal amplitude may be adjusted by moving the bucket to any fixed position along the beam in the radius range 0.10 m to 0.28 m, and mid-tide level may be adjusted by vertically shifting a movable base on which the motor rests (Fig. 2a).

DESCRIPTION OF TANKS AND RESERVOIRS

The tidal tanks are constructed of 18 mm thick, 7-layer, marine grade plywood, undersealed with "Everdure" epoxy resin and oversealed with "Epiglass" epoxy resin (Consolidated Chemicals Ltd, Auckland). Each tank is 1.5 m by 0.75 m by 0.6 m deep; each has three portholes cut into one of the long sides. A single sheet of glass was inserted into slots on the inside of each tank to cover the three portholes, and the glass was sealed into the slots with aquarium putty. The overhead reservoir is 1.19 m by 0.57 m by 0.3 m deep, contains up to 200 l, and is made of 13 mm thick, 5-layer, marine grade plywood coated similarly to the experimental tanks. The ground reservoir is a commercially available child's PVC "swimming pool" (Para Rubber Co., Christchurch), 0.45 m high and 2.28 m diameter. When the water level in the overhead reservoir drops to within 50 mm of the bottom, a float switch activates a fibreglass centrifugal pump (Marino Products, Brisbane) until the overhead reservoir is refilled from the ground reservoir. Water flows from the overhead reservoir by gravity feed through pipes (35 mm internal diameter) to the experimental tanks, at a rate controlled by valves in the pipes. This rate was set to provide a small overflow during the ascending phase of the tidal cycle. In practice the flow into each tank was about 2 l.min^{-1} and there was no turbulence associated with exchange or rise-and-fall of water. Internal diameter of the pipes leading to the overflow bucket was 30 mm. This was adequate to allow a rapid flow of water from the tidal tanks during ebb tide, with only a slight head difference between water levels in the tidal tanks and at the openings of the inlet pipes of the overflow bucket.





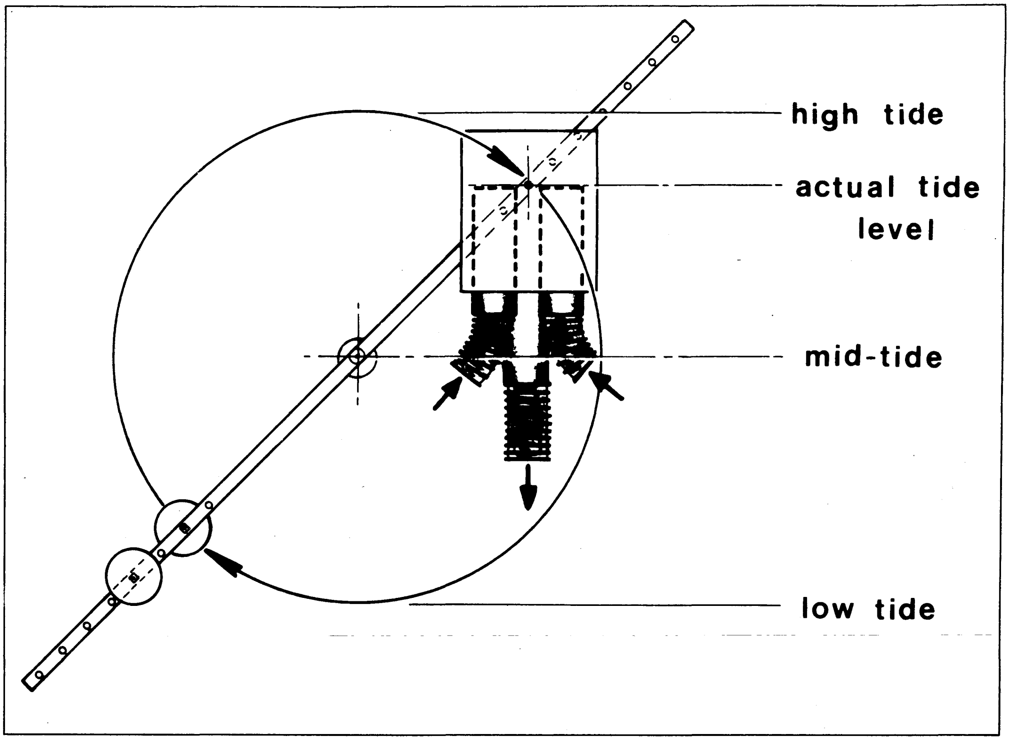


Fig. 3. Relationships of tide states to circle described by overflow bucket on the rotating beam.

DISCUSSION

The Bristol tide model described by Underwood (1972) had a maximum tidal amplitude of 0.50 m, with a single experimental tank of area 0.56 m by 0.50 m. The Kaikoura tide model has a similar maximum tidal amplitude (0.55 m), but two much larger experimental tanks (1.5 m by 0.75 m). These tanks accommodate boards (artificial "shores") of maximum dimensions 1.2 m by 0.9 m high, when the boards are placed in the tanks at a 45° slope to the vertical. The limitations on tidal amplitude and system capacity are a consequence of the size of the tidal tanks and reservoirs, but with the motor and tidal mechanism described, a tidal amplitude of over 1 m should be possible by simply extending the diameter of the rotating counterbalanced beam. No

Fig. 2a. General view of part of the tidal tank system. Centre bottom is ground reservoir; centre middle is one of the experimental tanks containing an artificial "shore" (1.2 m by 0.9 m high); centre right is tidal mechanism on a base which may be shifted vertically to any desired level; left top are pipes from overhead reservoir, which is out of photograph.

Fig. 2b. Motor and gearbox which drive the rotating counterbalanced beam. Attached to the beam is the overflow bucket with inlet and outlet pipes.

attempt was made to control water temperatures in the system, although this would be feasible if required. Tidal period was fixed at 12.5 h because of the motor and gearbox employed. Underwood (1972) used a larger, more expensive motor, with a rheostat to control motor speed and hence tidal period, and this would have advantages for some experimental situations.

A major problem with the Kaikoura model has been leakage of water through the putty sealing glass to the experimental tanks. With deeper aquaria and larger tidal amplitudes this would be even more of a problem unless viewing ports were considered unnecessary and not included in the tanks. Putty sealing would probably be undesirable if amplitudes were greater than about 0.6 m.

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LITERATURE CITED

EVANS, F. 1964. A tide generating machine for laboratory use. *Netherlands Journal of Sea Research 2*: 183-185.

________ 1965. The effect of light on zonation of the four periwinkles, *Littorina littorea* (L.), *L. obtusata* (L.), *L. saxatilis* (Olivi) and *Melarapha neritoides* (L.) in an experimental tidal tank. *Netherlands Journal of Sea Research 2*: 556-565.

LAMBERT, T.C. and FARLEY, J. 1968. The effect of parasitism by the trematode *Cryptocotyle linqua* (Creplin) on zonation and winter migration of the common periwinkle, *Littorina littorea* (L.). *Canadian Journal of Zoology 46*: 1139-1147.

MICALLEF, H. 1967. A portable tide-generating machine. *Netherlands Journal of Sea Research 3*: 598-600.

________ 1969. The zonation of certain trochids under an artificial tidal regime. *Netherlands Journal of Sea Research 4*: 380-393.

MORTON, B.S. 1970. The tidal rhythm and rhythm of feeding and digestion in *Cardium edule*. *Journal of the Marine Biological Association of U.K. 50*: 499-512.

OTTAWAY, J.R. 1973. Some effects of temperature, desiccation, and light on the intertidal anemone *Actinia tenebrosa* Farquhar (Cnidaria: Anthozoa). *Australian Journal of Marine and Freshwater Research 24*: 103-126.

________ and THOMAS, I.M. 1971. Movement and zonation of the intertidal anemone *Actinia tenebrosa* Farqu. (Cnidaria: Anthozoa) under experimental conditions. *Australian Journal of Marine and Freshwater Research 22*: 63-78.

THOMPSON, T.E. 1968. Experiments with molluscs on the shore and in a laboratory tide-model. *School Science Review 149*: 97-102.

UNDERWOOD, A.J. 1972. Sinusoidal tide models: design, construction and laboratory performance. *Journal of Experimental Marine Biology and Ecology 8*: 101-111.